ENVIRONMENTAL MONITORING OF FORESTRY CONTROL OPERATIONS (EMOFCO)

1988 REPORT

COMPILED BY:

W. A. SEXSMITH
NEW BRUNSWICK DEPARTMENT OF THE ENVIRONMENT

MATERIAL IN THIS REPORT MAY NOT BE CITED WITHOUT CONSULTATION WITH THE CONTRIBUTORS

1989

ABSTRACT

This multi-disciplinary compilation is concerned primarily with the environmental monitoring of the spruce budworm and the forest herbicide aerial spray operations in New Brunswick in 1988. However in 1988, little work relating directly to environmental monitoring was done. This report consists of nine reports dealing with operational, research and regulatory aspects of both spray programs. The pesticides investigated in New Brunswick and other jurisdictions are:

- insecticides - fenitrothion and Bacillus thuringiensis
- herbicides - glyphosate, hexazinone, triclopyr, sulfometuron-methyl and metsulfuron-methyl.

TABLE OF CONTENTS

	Page
ABSTRACT	i
FOREWORD	iv
RECOMMENDATIONS	v
INSECTICIDES	1
OPERATIONAL	1
1988 spruce budworm protection program in New Brunswick. N. Carter	1
Research	11
Review of pest management and development programs conducted in New Brunswick in 1988 against the spruce budworm (*C. fumiferana*) and the spruce budmoth (*Z. canadensis*) E.G. Kettela	11
Progress report on residual efficacy and dose transfer mechanism of Dipel 12L sprayed aerially against spruce budworm at Bathurst, during 1988. P. C. Nigam and S. E. Holmes	18
HERBICIDES	21
A summary of operational herbicide research being conducted by FPMI in New Brunswick. D. Pitt	21
REGULATORY ACTIVITIES	27
Operational forest spray monitoring. W. A. Sexsmith	27

MONITORING IN OTHER JURISDICTIONS..... 31

Environmental monitoring carried out for the aerial spraying of biological insecticides against the spruce budworm in Quebec in 1988.
S. Delisle, P. M. Marotte, and J. Cabana..... 31

Environmental monitoring carried out for the aerial spraying of insecticides against the spruce budmoth in Quebec in 1988.
S. Delisle, and P.-M. Marotte..... 35

Environmental monitoring of herbicide spraying carried out in Quebec in 1988.
J. Legris and S. Delisle..... 36

1988 hemlock looper control monitoring program in Newfoundland.
R. Martin..... 36

RECENT PUBLICATIONS..... 39

AUTHORS' AFFILIATIONS AND ADDRESSES..... 40

FOREWORD

The New Brunswick Committee for Environmental Monitoring of Forestry Control Operations (EMOFCO), formerly the New Brunswick Committee for Environmental Monitoring of Forest Insect Control Operations (EMOFICO), is an informal association of biologists, foresters, environmental specialists and chemists from federal and provincial governments, industry and universities. Its prime objective is to exchange information on the impact of operational spray programs, now including both herbicide and insecticide spray programs, on non-target organisms and ecological processes in forest and adjacent ecosystems. By implication this includes experimental sprays and complementary laboratory studies. Efficacy is also considered, insofar as it relates to environmental effects. The potential consequences of forest spray programs for human health are beyond the Committee's terms of reference. Although the Committee's focus is on spray activities in New Brunswick, it seeks to keep aware of forestry control operations and related environmental studies in the Atlantic region as well as in Quebec and Maine.

The Committee assumed its previous name and present structure in 1976, and has been under the aegis of the Department of the Environment since 1980. The Committee was modified in 1987 to incorporate forest herbicides into the terms of reference as a result of the increased interest in the use of these products as forest management tools. The 1988 report, like its predecessors, is aimed at a broad readership - scientists, regulators, resource managers and the public. It consists essentially of preliminary reports and abstracts of reports completed.

Steering Committee

D. C. Eidt (Canadian Forestry Service)
W. R. Ernst (Environment Canada)
W. A. Sexsmith, Secretary (N.B. Department of the Environment)
D. R. Silliphant, Chairman (N.B. Department of the Environment)

RECOMMENDATIONS

The following recommendations represent a consensus of the EMOFCO Committee. They have been developed from the information generated for the 1988 reports and from previous reports.

It is recommended

(1) that inasmuch as the operational use of fenitrothion at conventional dosages may sometimes affect negatively birds, pollinating insects, and aquatic invertebrates, more environmentally acceptable alternatives to present use patterns of fenitrothion must continue to be actively sought;

(2) that there be intensified effort into basic research on forestry insecticides which are environmentally acceptable;

(3) that inasmuch as biological impacts that have been measured after forestry insecticide spray programs may be associated with highly variable insecticide deposits, there be more effort made to determine the cause of this high variability and to determine the significance for non-target organisms;

(4) that inasmuch as plant pollination systems, which are dependent upon insects, may be critical ecological processes, forest spraying effects on such systems need to be further studied;

(5) that the indirect effects on forest fauna resulting from the knockdown of non-target insects by B.t., and the impacts of the long-term persistence of B.t. in forest soils and aquatic sediments, be investigated;

(6) that regulatory agencies continue to review the rationale for the specifications for environmental buffer zones, in keeping with information provided by spray technology research;

(7) that inasmuch as EMOFCO is now concerned with the environmental effects of forestry herbicides, which have received little environmental monitoring attention, efforts be made to review the present forestry herbicide environmental effects data base and identify research priorities for data gaps.

INSECTICIDES

Operational

1988 NEW BRUNSWICK PROTECTION PROGRAM AGAINST SPRUCE BUDWORM

N. Carter

Spruce Budworm Conditions in 1988

The 1988 aerial defoliation survey was conducted in the standard manner and revealed an estimated 43 000 ha of light, 196 000 ha of moderate, and 304 000 ha of severe defoliation (Figure 1). Approximately 65.5% of the moderate-severe (M-S) defoliation was outside the treated areas. Defoliation was detected in largest concentrations throughout the North-central part of the Province, primarily in Restigouche County. Except for occasional small pockets of defoliation, the majority of the rest of the province was undamaged. The 500 000 ha of M-S defoliation represents a 16% increase from 1987, but is still 75% below the 2.03 million ha in 1983.

1988 Spray Program

The 1988 spruce budworm spray program (Figure 2) conducted by Forest Protection Limited, in New Brunswick covered approximately 448 500 hectares. This is 6.3% less than the 478 000 ha treated in 1987. Another 98 000 ha were sprayed by J.D. Irving Ltd. on its own freehold limits (compared to 105 000 ha in 1987).

Of the total area treated by FPL, 51.5% received a double application of the chemical fenitrothion (Sumithion) and 1.4% received a single application. About 47.0% of the area received a single treatment of bacterial insecticide, *Bacillus thuringiensis* var. *kurstaki* (*B.t.*) in the form of two products, viz Futura XLV (41.2%) and Dipel 132 (5.8%) (Table 1).

Spray aircraft included 12 TBMs, 1 four-engine DC-6, and 2 single-engine agricultural-type small spray planes (SSPs). TBMs were used to treat 58% of the total area and the DC-6 treated 41% of the area. This year's program was characterized by the largest area (210 000 ha) and proportion (47%) of *B.t.* in any of New Brunswick's spray programs to date. The Dipel 132 was sprayed by TBMs; the Futura XLV was primarily sprayed by the DC-6 (a few small blocks were done with SSPs).

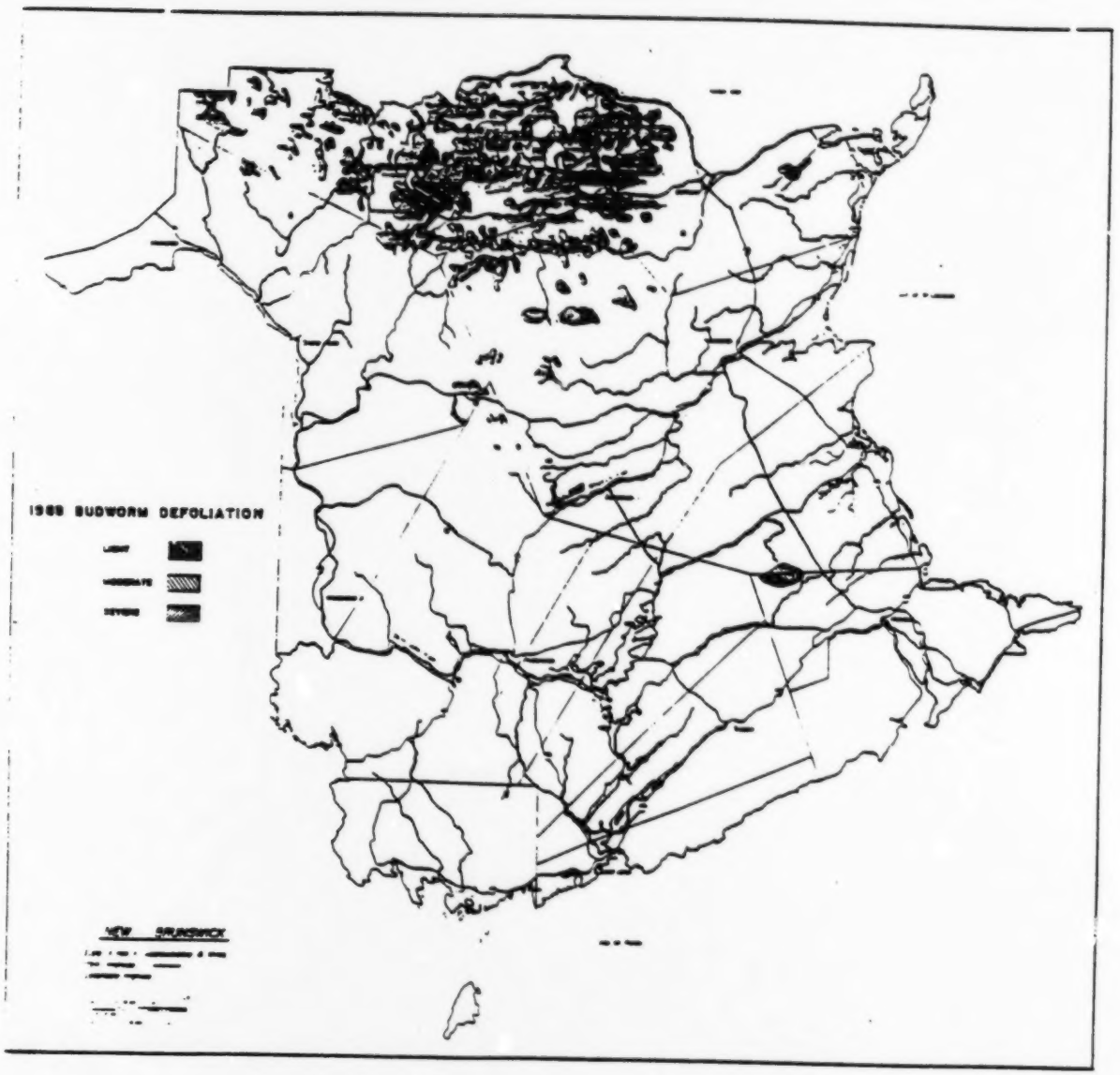

Figure 1. Areas of light, moderate and severe defoliation based on 1988 aerial defoliation survey.

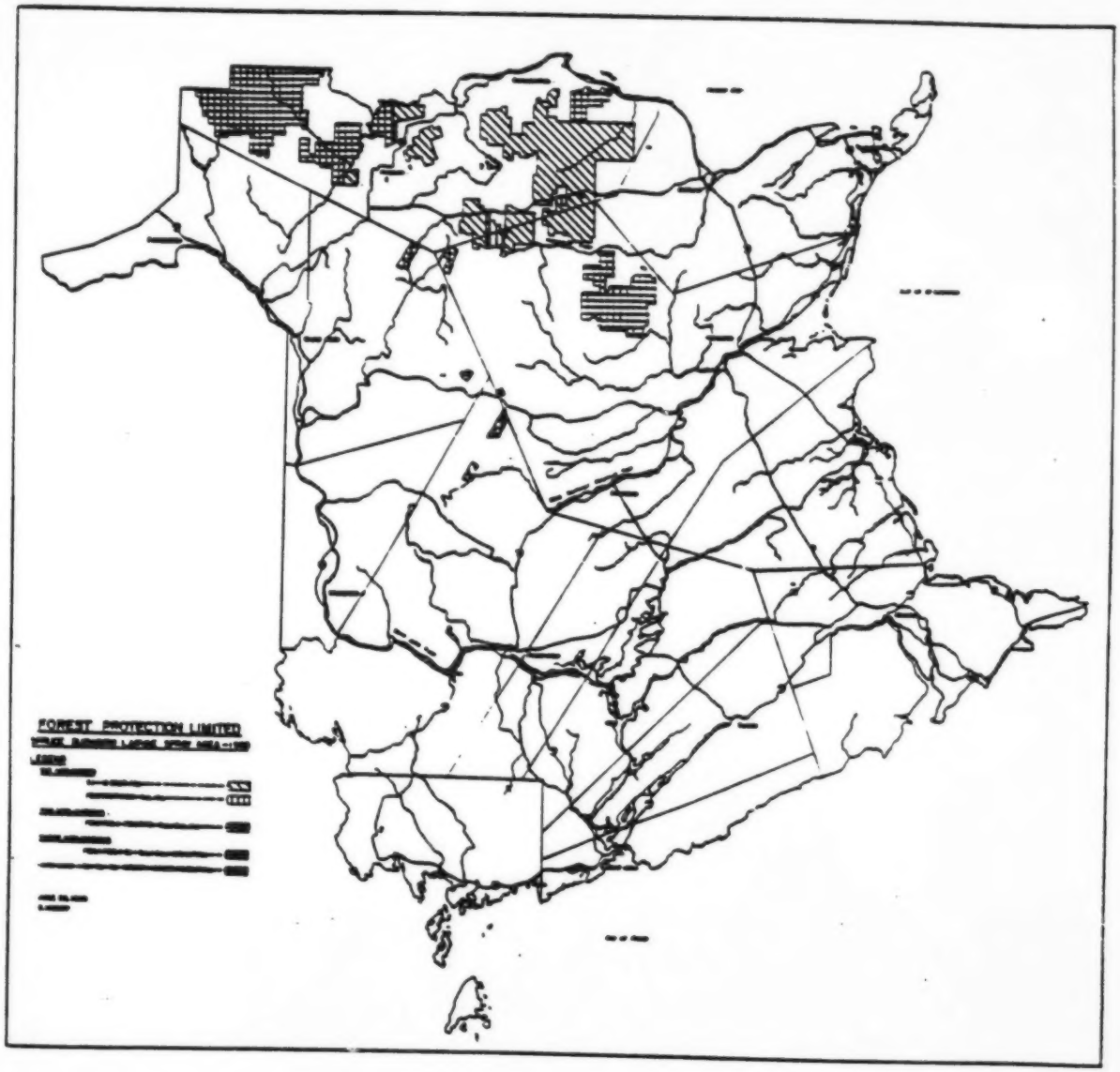

Figure 2. Areas sprayed by FPL for spruce budworm control in New Brunswick in 1988. (Does not include J. D. Irving Ltd. program).

Table 1. Areas sprayed by Forest Protection Limited for spruce budworm control in 1988 in New Brunswick*. (Does not include J.D. Irving program).

Treatment	Hectares Thousands	(%)	Acres Thousands	Aircraft Type
One Application - Biological				
30 B.I.U./ha B.t. (Dipel 132)	26.0	(5.8)	64.0	TBM
30 B.I.U./ha B.t. (Futura XLV)	184.5	(41.2)	456.2	DC-6,
SUB-TOTAL	210.5	(47.0)	520.2	Ag Truck
One Application - Chemical				
280 g/ha Fenitrothion	6.3	(1.4)	15.5	TBM
Two Applications				
210 g/ha Fenitrothion+ 210 g/ha Fenitrothion	231.1	(51.5)	571.0	TBM, Ag Truck
SUB-TOTAL	237.4	(53.0)	586.5	
Three Applications (Seed Production Areas) 210 g/ha Fenitrothion + 210 g/ha Fenitrothion + 30 (B.I.U./ha (Futura XLV)	0.6	(0.1)	1.5	Ag Truck
GRAND TOTAL	448.5	(100.0)	1108.2	

*Source: Forest Protection Ltd.

The first operational spray blocks* were declared biologically ready for chemical spraying on May 24th and spray operations commenced that morning. The first B.t. blocks were declared biologically ready on May 27th and spraying began the next day. The operational program was completed on the evening of June 13th. Better than usual spray weather was experienced throughout the spray period although mean daily temperatures were cool.

Results of Spray Program

This year's B.t. program was the largest ever conducted in New Brunswick. It took place in the north where last year's forecast revealed a very significant increase in budworm population levels over the previous year. B.t. and fenitrothion were used over approximately 210 000 ha and 238 000 ha, respectively. Although the forest received some benefits due to B.t. treatment, results were far superior with fenitrothion (Table 2; Figures 3 & 4).

For instance, budworm mortality due to fenitrothion averaged 72%, compared to 50% for B.t.; mean branch defoliation in fenitrothion plots was only 34% compared to 68% in B.t. plots; and percent reduction in defoliation in fenitrothion plots averaged 61%, but was only 24% in B.t. plots. Furthermore, only 19% of the fenitrothion area had moderate and severe defoliation compared with 60% of the B.t. area. The area of moderate and severe defoliation in protected areas using fenitrothion is much closer to the previous 11-year average of 14% (range 6% to 20%) in programs based almost solely on chemical treatments.

There is no single explanation for the poor results with B.t. in 1988. There is a myriad of factors which could have influenced the results. The following facts are known. Population levels were higher this year than in operational B.t. treatment blocks for the past several years. B.t. has primarily been sprayed in the south under conditions of declining populations in past programs. Defoliation levels were more severe at any given population in the north this year compared to levels seen in the southern part of the Province in the past few years. This year's B.t. program was large-block spraying with large aircraft. Past B.t. programs were primarily small blocks sprayed by small aircraft and timed for either fir or spruce depending on predominant host. Because spray blocks were so large this year the topographic variability resulted in insect and tree development being more diverse within the blocks. A single application of insecticide (B.t. or chemical) cannot adequately address this variability. Topography can adversely influence aircraft application height, but there were no measures of deposit to confirm whether deposit was adequate or not. Finally,

*Excludes three small black spruce seed production areas.

Table 2. Summary of data collected from balsam fir samples in fenitrothion, B.t. and check plots in 1988.

Block	Lines*	Aircraft	n	Pre-spray Larvae Per 45-cm	Pre-spray Larvae Per Bud	% Mortality Obs.	% Mortality Corr.	Defoliation Obs.%	Defoliation %Red.
KENRICK									
Fenitrothion - 2 x 210 g/1.46 L/ha									
A-1	50-85	TBM	40	32.8	0.520	84.6	42.8	38.7	58.1
A-2	21-42	TBM	40	23.2	0.269	85.2	54.5	43.8	53.3
A-2	52-67	TBM	40	21.8	0.422	91.4	66.1	32.8	62.6
A-2	70-92	TBM	40	22.1	0.308	89.2	63.4	41.4	53.2
A-3	5-20	TBM	40	14.3	0.178	83.7	66.7	32.8	57.9
A-4	55-76	TBM	40	8.9	0.149	97.4	95.1	14.4	82.3
A-5	37-55	TBM	40	17.8	0.217	94.9	86.1	27.5	66.7
Bacillus thuringiensis									
Dipel 132 - 1 x 30 BIU/2.36 L/ha									
A-6	44-52	TBM	40	16.3	0.232	83.4	61.4	46.5	41.0
A-7	9-25	TBM	40	21.9	0.244	87.2	83.8	62.0	24.4
Futura XLV - 1 x 30 BIU/2.03 L/ha									
D-2	10-26	DC-6	40	14.2	0.235	87.8	71.6	27.4	64.4
D-2	72-90	DC-6	40	39.3	0.659	94.3	70.2	94.2	4.2
Untreated									
Check 1	-	-	35	11.1	0.189	57.5	-	56.4	-
Check 2	-	-	40	18.5	0.236	58.3	-	72.5	-
Check 3	-	-	40	19.2	0.256	63.6	-	95.9	-
Check 4	-	-	40	11.4	0.151	32.0	-	72.1	-
CAMPBELLTON									
Bacillus thuringiensis									
Futura XLV - 1 x 30 BIU/2.03 L/ha									
D-1	10-30	DC-6	40	40.8	0.603	87.2	58.4	78.9	16.8
D-1	42-65	DC-6	40	27.3	0.288	83.5	50.9	64.0	25.3
D-1	75-85	DC-6	40	45.6	0.605	88.1	61.4	69.5	25.9
D-1	95-112	DC-6	40	38.8	0.515	74.8	0.1	74.3	22.0
D-1	120-140	DC-6	40	28.6	0.383	74.3	0.0	73.9	15.0
D-1	125-145	DC-6	40	20.5	0.430	78.2	14.2	70.2	21.6
D-1	75-90	DC-6	40	45.1	0.539	91.9	73.0	91.5	3.9
Untreated									
Check 1	-	-	40	30.1	0.427	79.2	-	96.9	-
Check 2	-	-	40	30.0	0.479	73.7	-	98.1	-
Check 3	-	-	40	24.7	0.383	79.3	-	90.8	-
Check 4	-	-	40	52.8	0.753	64.8	-	99.7	-
Check 5	-	-	40	34.5	0.439	66.3	-	97.5	-
SEVOGLE									
Fenitrothion - 2 x 210 g/1.46 L/ha									
A-13	10-24	TBM	40	40.2	0.582	93.7	76.1	56.3	40.6
A-15	20-23	TBM	40	12.9	0.187	99.6	99.2	17.0	77.7
Untreated									
Check 1	-	-	40	25.5	0.307	80.6	-	60.9	-

* Portion of block that was sampled.

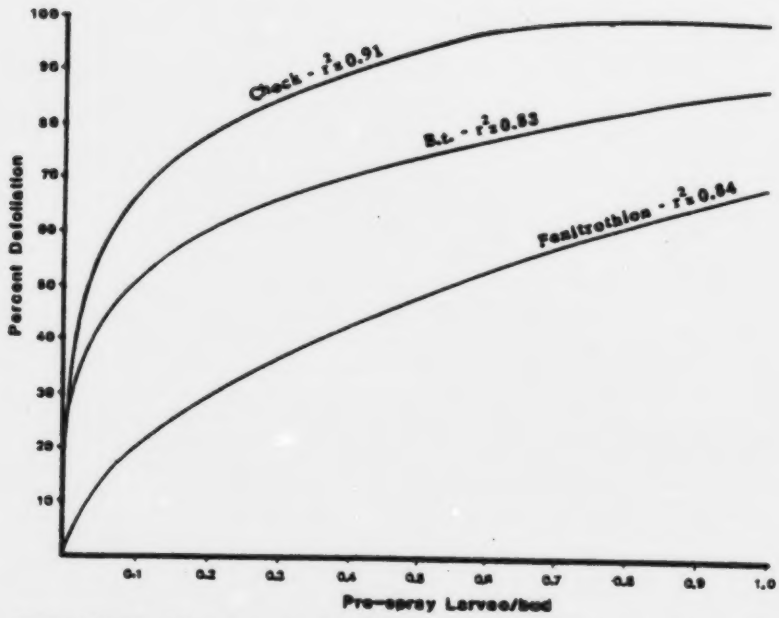

Figure 3. Comparison of percent defoliation on balsam fir from treatment and check plots.

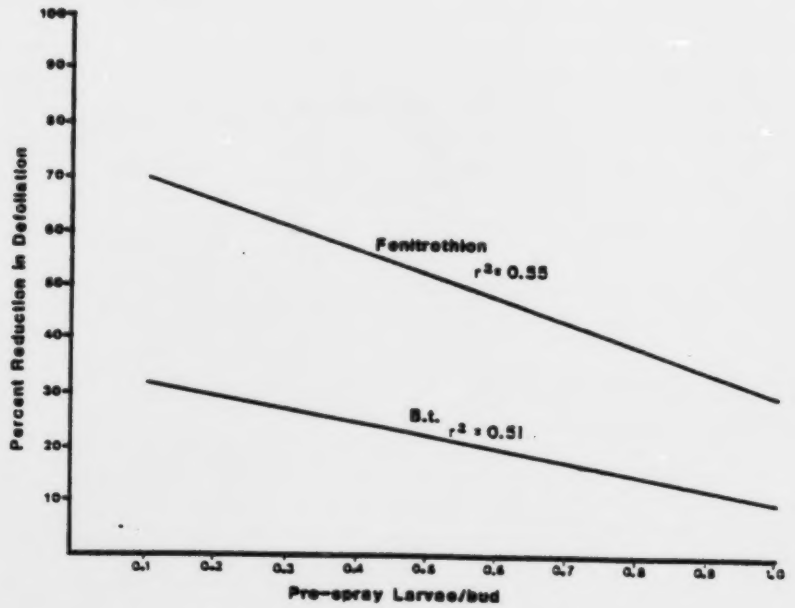

Figure 4. Comparison of percent reduction in defoliation on balsam fir in plots treated by Fenitrothion and B.t.

Table 3. Comparison of Spruce Budworm Forecast Infestation Levels 1981-1988.

YEAR	FORECAST INFESTATION LEVEL			
	LOW	MODERATE	HIGH	LOCATIONS[a]
1981 egg-mass	591 (34%)	441 (25%)	708 (41%)	1740
1982 egg-mass	458 (26%)	512 (29%)	783 (45%)	1753
1983 egg-mass	636 (48%)	257 (20%)	423 (32%)	1316
1984 egg-mass	747 (51%)	331 (22%)	398 (27%)	1476
1985 L2	833 (56%)	503 (32%)	185 (12%)	1521
1986 L2	1216 (77%)	322 (20%)	48 (3%)	1586
1987 L2	1198 (76%)	230 (15%)	144 (9%)	1572
1988 L2	879 (73%)	226 (19%)	99 (8%)	1204[b]

a - Supplementary sampling not included.
b - Fewer samples taken because of collapse in southern part of province.

Table 4. Comparison of Forecast Area (ha) of Moderate and High Infestations 1982-1988.

YEAR (N)	(N + 1) FORECAST
1982	5.30 million ha
1983	4.10 million ha
1984	3.57 million ha
1985	3.15 million ha
1986	1.71 million ha
1987	1.50 million ha
1988	1.65 million ha

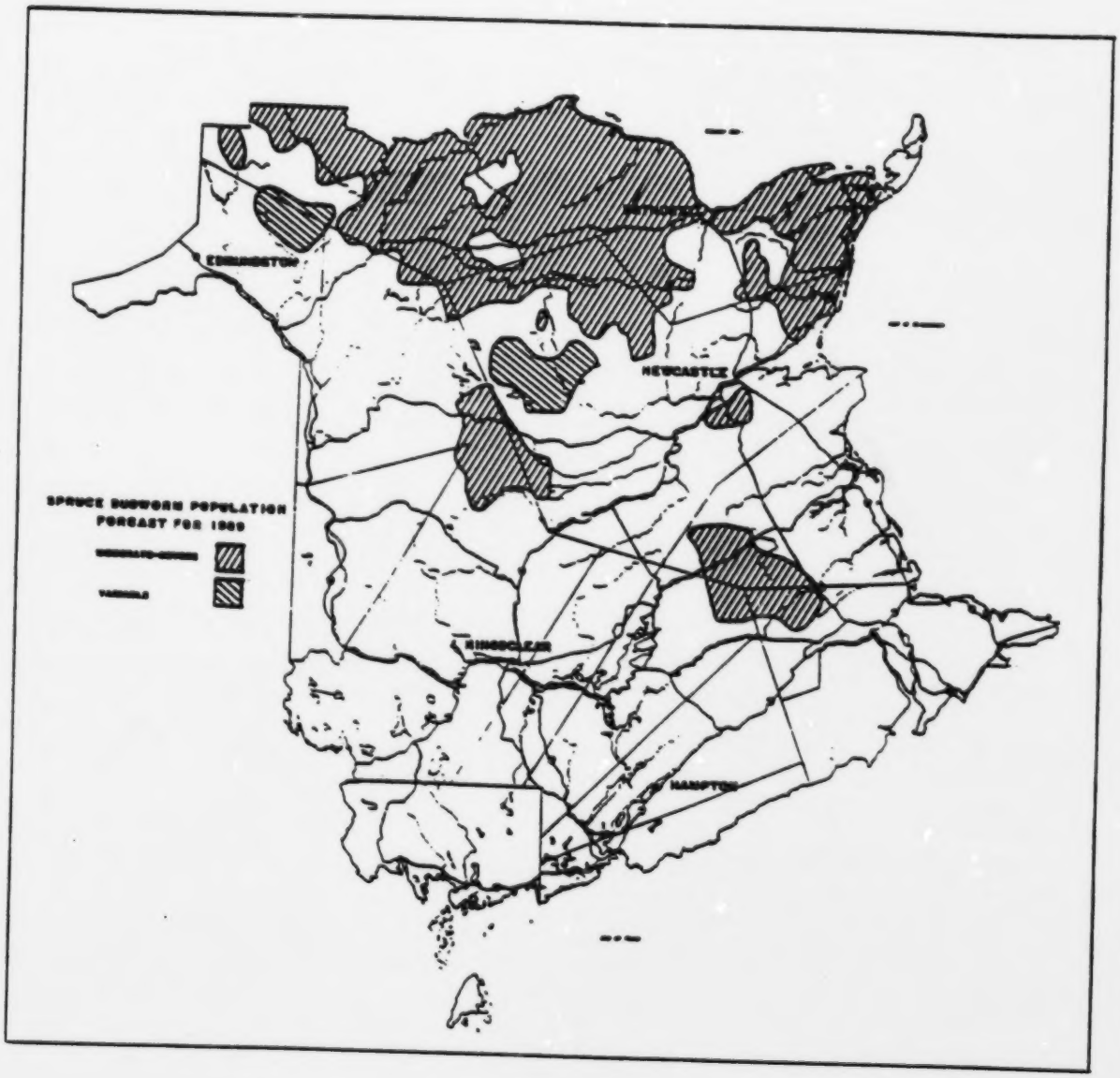

Figure 5. Areas forecast to have moderate and high infestation levels in 1989 based on the 1988 L2 survey.

there was a cool spell which coincided with the spray period and might have suppressed larval behaviour mitigating against good B.t. results.

Forecast of Infestation for 1989

The spruce budworm egg mass survey was replaced by the L2 survey in 1985 as the method of forecasting infestation levels in New Brunswick. Table 3 compares the proportion of sample points within each infestation category used in the initial forecasts from 1981 to 1988. Between 1982 and 1986 there was an increasing trend in the percent of points in the Low category with a corresponding decreasing trend for the High category. In 1987, there was a three-fold increase in the proportion of points in the High category in the North-central to North-western parts of the Province and within Restigouche County the population increased by an average of 15 L2/branch. This year, in the same county, there was a decrease in overall mean L2/branch, (1987 = 24 L2/branch; 1988 = 14 L2/branch). Hundreds of supplementary L2 samples are also collected throughout the winter months to assist in planning the protection program.

The forecast for 1989 is for 1.65 million ha (Figure 5) of variable and moderate to high infestation, which is a 10% increase from last year's forecast (Table 4). The most severe damage is again expected in the northern part of the Province with an extension to the northeast. A few pockets remain in the central area. No significant damage is expected in the southern half of the Province with the exception of one area northwest of Moncton.

Plans for 1989

Spray plans for 1989 have not been formulated at this time. Nevertheless, it does appear that a protection program will be required in New Brunswick next year. Whether a combination of chemical insecticides and B.t. will again be used is presently not known. Tentative spray plans should be known by mid-December.

Research

Review of Pest Management Research and Development Programs conducted in New Brunswick in 1988 Against the Spruce Budworm (*C. fumiferana*) and the Spruce Budmoth (*Z. canadensis*)

E. G. Kettela

Introduction

The following brief summary covers work conducted under study 2329 of Forestry Canada - Maritimes. This includes work with new *B.t.* products and use tactics against the spruce budworm, development of control strategies for the spruce budmoth (adulticiding with fenitrothion), and the development of pheromone as a pest management tool of the spruce budmoth. The work with pheromones is a joint effort of Forestry Canada and the New Brunswick Research and Productivity Council. For interests sake, although not specifically spraying I also refer to work done with the introduction of exotic parasites. In addition to the staff and internal funding assigned to this project, funding from external sources provided substantial support. Funding agencies were Forest Protection Ltd., C.I.L., Chemagro, NOVO, J.D. Irving Ltd. and Forestry Development.

Development of B.t. Products and Tactics

- Reduced dosage/enhanced atomization

In 1988 we had the opportunity to further test the concept of reduced dosage/enhanced atomization of *B.t.* for control of spruce budworm. This was possible because two *B.t.* manufacturers made available very high potency products, namely, Chemagro with FUTURA XLV-HP and Abbott with Dipel 12L and 16L. The practical development of the reduced dosage/enhanced atomization use of *B.t.* hinges on the availability of such high potency materials and the equipment for its application. In all, 12 treatment sites were sprayed; with Dipel 12L (4), Dipel 16L (4) and FUTURA XLV-HP (4) and 2 blocks each at 15 BIU/ha and 30 BIU/ha. Application of the sprays was made with a team of Cessna 188 spray aircraft equipped with Micronaire AU 4000 rotary atomizers set to operate at maximum, with a flow rate of no more than 2 litres per head per minute for the 15 BIU/ha treatments and twice that for the 30 BIU/ha treatments. Navigation of the spray aircraft over the treatment sites was accomplished with Cessna 172 navigation aircraft. The general locations of all *B.t.* testing in 1988 are shown in Figure 1. Results of treatment are summarized in Tables 1 and 2. Data from spray blocks treated with registered *B.t.* are included for comparison purposes. The

bottom line is that the reduced dosages of FUTURA XLV-HP and both DIPEL 12L and 16L (15 BIU/ha) provided foliage protection similar to the higher dosages of these products and similar to protection provided by the registered B.t. supplied at higher volumes of spray/ha. This confirms the findings of spray trials in 1987.

- Testing of new products

In addition to the previous work we had the opportunity to test two new B.t. products, one manufactured by C.I.L., the other by NOVO. This work was undertaken by Research and Productivity Council and Forestry Canada. Test sites were located in northeast New Brunswick (Fig. 1) and consisted of 4 treatment sites, one each of CIL-E492 and FORAY 48 and two of FUTURA XLV. All treatments were at 30 BIU/ha. Block size was 200 ha for the FUTURA XLV and FORAY 48 and 100 ha for the CIL-E492. The results of spray efficacy are shown in Tables 3 and 4. Both products provided adequate protection to foliage and the results were similar to that provided by the treatments with registered B.t.

Development of Control Practices for Zeiraphera canadensis

- Treating adults with fenitrothion

The spruce budmoth (Zeiraphera canadensis) continues to be a very important pest of newly established white spruce plantations. Except for permethrin no other insecticide has shown any significant efficacy when applied against larvae of the spruce budmoth. However, initial investigation into the efficacy of aminocarb and fenitrothion against adults of this insect showed a very significant protection result in the next year. Dosages as little as 105 g/ha of fenitrothion impacted significantly on generation survival. The work done in 1988 investigated the efficacy of one application of fenitrothion at 105 g/ha when applied during the emergence phase of adults as determined through trapping of adults with pheromone traps. Ten treatment sites were investigated. Unfortunately in 1988 we had a set back with the lures used in the traps for timing the treatments so we had to go to an ocular estimate of adult activity. Basically in all treatment sites, adult activity ceased 48 hours post treatment. This was similar to other treatments made in 1986 and 1987 and indicates a delayed action of the fenitrothion. The bottom line is the impact on the next generation. Egg counts in treated and non-treated sites showed in excess of a 90% reduction in eggs laid due to treatment confirming the results previously measured.

All spraying of Zeiraphera adults was conducted by Forest Patrol Limited on J. D. Irving Ltd. lands in northwestern New Brunswick. Treatment was accomplished with Thrush commander aircraft equipped with Micronair AU 4000 atomizers.

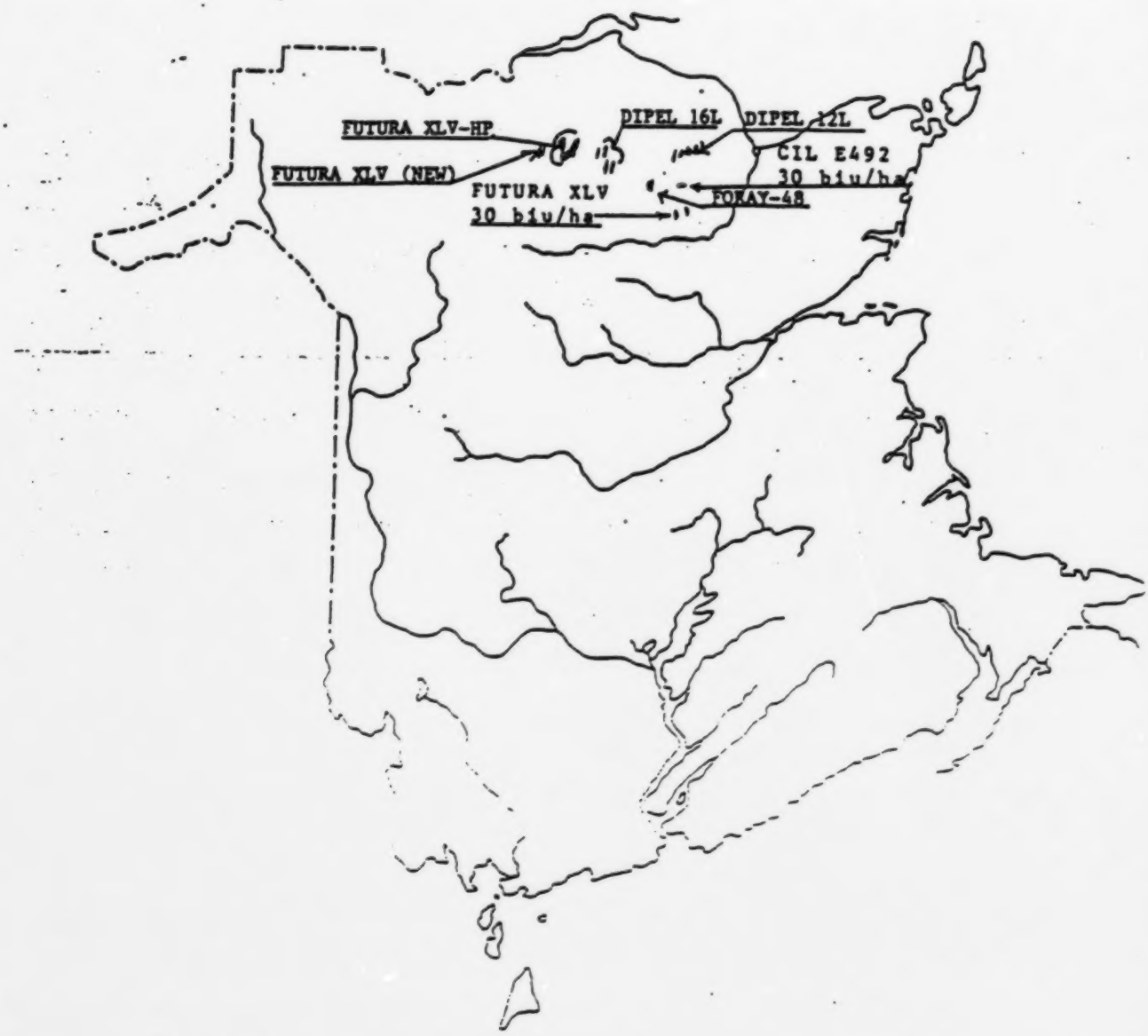

Figure 1. Location of B.t. experimental treatment areas in New Brunswick in 1988.

Table 1. Synopsis of results of spray efficacy trials with FUTURA XLV, and FUTURA XLV (new production method) applied at 30 BIU/ha and FUTURA HP applied at 30 and 15 BIU/ha, in New Brunswick in 1988.

Block no. treatment	No. sample trees	Development index		Budworms/ 45-cm branch			Survival			Defoliation				Deposit
										Observed				
		Larvae	Shoots	Pre-spray 2 day	Post spray 4 day	Post spray Final	Obs.	Exp.	% red	Day of spray	Final	Exp.	% reduction	Drops/ Needle
5A FUTURA HP 30 BIU/ha 1.1 l/ha	60	5.3	5.0	20.2	4.6	3.2	15.8	30	47	28	30	63	52[a]	0.18
5B FUTURA HP 15 BIU/ha 0.55 l/ha	60	5.3	5.0	29.1	4.8	3.5	12.0	32	63	25	31	80	61[a]	0.21
4 FUTURA XLV New 30 BIU/ha 2.0 l/ha	60	4.9	5.0	30.4	-	3.7	12.3	33	69	29	31	85	64[a]	0.16
10 FUTURA XLV 30 BIU/ha 2.0 l/ha	60	4.6	4.0	23.0	-	0.5	2.3	29	92	-	21	64	67[a]	0.16
8 FUTURA XLV 30 BIU/ha 2.0 l/ha	60	4.3	4.5	16.8	-	0.7	4.2	31	86	-	15	45	67[a]	0.12

[a] - No significant difference at 0.05 level

Table 2. Summary of results of spray trials with Dipel 12L and 16L sprayed at two dosage rates and compared to unsprayed control data and results obtained with Futura XLV (standard operational treatment). All blocks treated with Cessna 188 aircraft equipped with Micronaire AU 4000 nozzles, 1988.

Treatment	Budworms/branch (45-cm tip)			Survival %	Defoliation			Development Index		Spray deposit drops/needle
	Pre-spray	5-day post	Final post spray		Obs* 1	Obs* 2	Expt.	Larvae	Shoots	
DIPEL 12L										
30 BIU in	15.9	5.8	0.35	3.6	-	30	52	4.8	4.5	1.06
1.1 l.ha	28.4	2.8	0.25	0.8	-	38	75	4.8	4.5	0.58
15 BIU in	20.6	5.1	0.00	0	-	23	65	4.8	4.5	0.68
0.55 l/ha	40.5	8.0	1.15	2.8	-	56	95	4.8	4.5	0.54
DIPEL 16L										
30 BIU in	29.4	-	3.20	10.9	40	46	80	5.8	5.0	1.02
0.8 l/ha	45.1	-	2.10	4.7	49	57	95	5.8	5.0	1.29
15 BIU in	9.4	-	1.55	16.5	28	37	42	5.8	5.0	0.42
0.40 l/ha	20.4	-	1.90	9.3	32	39	65	5.8	5.0	0.56
FUTURA XLV										
30 BIU in	16.8	-	0.70	4.2	-	27	55	4.8	4.6	0.12
2.02 l/ha	22.0	-	0.50	2.3	-	36	69	4.8	4.6	0.16
UNSPRAYED CONTROLS	37.6	-	6.50	17.3	-	82				
	35.9	-	4.90	13.6	-	68				
	15.0	-	4.80	32.0	-	53				
	7.6	-	3.10	40.7	-	22				

*Obs Defoliation 1 - defoliation evident on the day of treatment
2 - final defoliation estimate.

Table 3. Results of spray efficacy of two B.t. preparations, FORAY 48B and FUTURA XLV (2 blocks) applied to balsam fir/spruce forest infested with the spruce budworm in New Brunswick in 1988

Block and treatment	No. of sample trees	Development index		Budworm/branch		Mean survival %			% Defoliation			Deposit
		Larvae	Shoots	Pre-spray	Post-spray	Obs.	Exp.	% Red	Obs.	Exp.	% Red	Drops/ Needle
6-FORAY 48B 30 biu/ha (2.4 l/ha)	43*	4.8	4.7	12.5	0.9	7.9	33	64[b]	19	40	36[b]	0.31
FUTURA XLV 30 BIU/ha (2.0 l/ha)	60	4.6	4.0	22.0	0.5	2.3	29	81[a]	21	64	57[a]	0.161
FUTURA XLV 30 BIU/ha (2.0 l/ha)	60	4.3	4.5	16.8	0.7	4.2	31	88[a]	15	45	36[b]	0.164
Unsprayed controls	25	-	-	52.2	4.8	9.0			95			
	20	-	-	37.6	6.5	17.0	-	-	82	-	-	
	20	-	-	35.9	4.9	13.0	-	-	68	-	-	
	20	-	-	15.0	4.8	32.0	-	-	53	-	-	
	20	-	-	7.6	3.1	40.0	-	-	22	-	-	
	20	-	-	6.5	1.2	18.0	-	-	19	-	-	

% Reduction in survival and defoliation calculated using Abbott's formula.

Expected defoliation and survival derived from regressions of defoliation and survival versus larval population intensity in untreated controls.

[a,b]Indicate tests for significant differences.

* Population data for 17 trees was discarded because of very low pretreatment populations (less than 5/branch)

Table 4. Results of spray efficacy of two B.t. preparations, CIL-E492 and FUTURA XLV (2 blocks) applied to balsam fir/spruce forest infested with the spruce budworm in New Brunswick in 1988

Block and treatment	No. of sample trees	Development index		Budworm/branch		Mean survival %			% Defoliation			Deposit
		Larvae	Shoots	Pre-spray	Post-spray	Obs.	Exp.	% Red	Obs.	Exp.	% Red	Drops/ Needle
5-CIL-E492 30 biu/ha (1.8 l/ha)	60	4.4	4.2	23.0	2.5	10.9	29	60[b]	22	65	40[b]	0.437
FUTURA XLV 30 BIU/ha (2.0 l/ha)	60	4.6	4.0	22.0	0.5	2.3	29	81[a]	21	64	57[a]	0.161
FUTURA XLV 30 BIU/ha (2.0 l/ha)	60	4.3	4.5	16.8	0.7	4.2	31	88[a]	15	45	36[b]	0.164
Unsprayed controls	25	-	-	52.2	4.8	9.0			95			
	20	-	-	37.6	6.5	17.0	-	-	82	-	-	
	20	-	-	35.9	4.9	13.0	-	-	68	-	-	
	20	-	-	15.0	4.8	32.0	-	-	53	-	-	
	20	-	-	7.6	3.1	40.0	-	-	22	-	-	
	20	-	-	6.5	1.2	18.0	-	-	19	-	-	

% Reduction in survival and defoliation calculated using Abbott's formula.

Expected defoliation and survival derived from regressions of defoliation and survival versus larval population intensity in untreated controls.

[a,b]Indicate tests for significant differences.

- Treatment of Zeiraphera with pheromones

The work with Zeiraphera pheromones was sponsored through the New Brunswick Forestry Development Agreement. The trial in 1988 was the culmination of work from the previous 2 years. Two treatment sites, 25 ha each, were treated; one with 50 g/ha and the other at 10 g/ha of pheromone in the ICI microcap formulation. Application was accomplished with a Cessna 188 aircraft equipped with raindrop nozzles. Results are presented in a report submitted as per agreement with funding agencies. Basically the results indicated that the 10 g/ha dose provided a measure of population reduction and mating disruption.

The results indicated that further work was needed on the pheromone blend chemistry, formulations and population sampling. Further tests are planned for either 1990 or 1991.

- Biological control of Zeiraphera

In 1988 work with two exotic parasites obtained through the Commonwealth Institute of Biological Control was continued. A third parasite was to be worked with, but all specimens received in Ottawa died. This was a species of Trichogramma from Zeiraphera sp. in Denmark.

The two parasites experimented with in the lab were Phytodietus griseana and Tranosema carbonellum. P. griseana demonstrated that it would oviposit in late instar larvae of Zeiraphera. These were reared through but no new generation P. griseana were obtained. Tests with T. carbonellum were unsuccessful, for only male parasites successfully emerged from the samples obtained. Further testing will continue as material becomes available.

Progress Report on Residual Efficacy and Dose Transfer Mechanism of Dipel 12L Sprayed Aerially Against Spruce Budworm at Bathurst, During 1988

P. C. Nigam and S.E. Holmes

Introduction

Bacillus thuringensis (B.t.) is becoming the material of choice for use against spruce budworm in North America. In order to increase its efficacy, competitiveness with chemicals and to reduce its application cost, highly concentrated formulations are being produced by different commercial companies and are being tried neat at ultra ultra low volume rates with finer atomization. It is hypothesized that finer atomization will

provide better coverage and the number of droplets reaching the feeding site will increase, more dose per insect will be delivered due to high concentration at active ingredient (AI) per drop in neat formulation and finally the cost of application will be reduced.

This study was carried out with the new concentrated oil formulation, Dipel 12L, developed by Abbott Laboratories. Experiments were carried out in cooperation with Mr. E. G. Kettela, Canadian Forestry Service - Maritimes (CFS-M), Forest Protection Limited (F.P.L.), Research and Productivity Council (R.P.C.) and Abbott Laboratories under the auspices of New Brunswick Spray Efficacy Research Group (NBSERG).

The objectives of this study were to determine (i) residual efficacy of Dipel 12L aerially atomized by Micronair AU4000 in coarse and fine droplets by using 30 BIU/ha in 1.1 L and 15 BIU/ha in 0.55 L/ha respectively, (ii) droplet deposits on needles, (iii) droplet characteristics and spectrum on webbing, (iv) dose transfer mechanism of AI to feeding site, using video recording for larval and droplet interaction.

RESULTS

A tentative summary of results is as follows:-

1. There was no difference in larval mortality of 15 and 30 BIU treatments up to 9 days observation. Mortality at adult emergence in 1 and 72 h samples of 30 BIU was significantly higher than 15 BIU and mortality in 24 h samples of 15 and 30 BIU was not significantly different.

2. Mean deposit counts of 1-year-old needles from 15 and 30 BIU plots were not significantly different. Although 30 BIU plot shows a trend of more deposit on trees as compared to 15 BIU plot, dye particle counts on tree No. 12 and 19 in 15 BIU plot are bringing mean deposit count closer to 30 BIU plot. Deposit count on 1-year-old needles does not reflect actual contamination of feeding site.

3. Analysis of droplet spectrum on webbing shows more smaller droplets in 15 BIU plot as compared to 30 BIU. This deposit spectrum is more useful in evaluation of efficacy than deposit on 1-year-old needles.

4. Video observations showed that droplets were transferred from webbing to setae of the larvae and from setae to covered feeding site inside the developing buds by movement of contaminated larvae, because very few droplets reach directly to the needles inside the buds on which larvae feed at this stage.

CONCLUSION

There was no difference in residual efficacy of 15 and 30 BIU spray formulations of Dipel 12L as applied during these experiments. It appears finer droplets of 15 BIU formulation were causing more contamination of feeding sites of larvae. These results were substantiated by data of Mr. E.G. Kettela on population survival and foliage defoliation, as 30 BIU gave 2.2% survival and 27% observed defoliation, while 15 BIU gave 0% survival and 23% observed defoliation in these experiments.

These results show a trend that 15 BIU give better efficacy than 30 BIU, but they are not significantly different. Dipel 12L applied at 15 and 30 BIU gave similar efficacy for foliage protection and larval mortality under the experimental conditions in the field.

It appears cost of material and application can be reduced substantially by applying neat oil formulation of Dipel 12L at 15 BIU with finer atomization.

HERBICIDES

A SUMMARY OF THE OPERATIONAL HERBICIDE RESEARCH BEING CONDUCTED BY FPMI IN NEW BRUNSWICK

D. Pitt

The Forest Pest Management Institute (FPMI) conducts operational conifer release and site preparation trials that are designed to evaluate the efficacy, crop tolerance, and crop growth response aspects of various forestry herbicides and herbicide use strategies. The following paper briefly outlines new and ongoing herbicide research that FPMI has been involved with in New Brunswick this past year.

New Operational Herbicide Research

This past summer, FPMI worked cooperatively with the New Brunswick Department of Natural Resources and Energy and the Canadian Forestry Service, Maritimes, to establish a trial designed to develop an improved-use strategy for VISION (glyphosate). The trial was conceived early last spring and finalized in May 1988, after the cooperators attended a New Brunswick Spray Efficacy Research Group (NBSERG) meeting in Fredericton.

At this meeting, the fact that there exists little herbicide application technology, developed specifically for forestry, was cited as a major concern. For example, in New Brunswick forests alone, more than 6 million dollars are being spent annually on VISION application with techniques adopted from agriculture, rights-of-way, and insect control - techniques that may not offer maximum efficacy at minimum cost. It was agreed that VISION is currently well established as being the most effective broad-spectrum herbicide available and significant cost savings may be realized by finding more effective and efficient methods of applying it.

Recent work with glyphosate suggests that efficacy can be improved through the use of small droplet sizes (200 to 350um) at low carrier volumes (47 to 35 l/ha) (Bode and Butler, 1982; Prasad and Cadogan, 1987; Prasad and Cadogan, 1988; Brunsdon, 1988). In this light, the trial conducted by FPMI this summer is designed to compare the efficacy and crop tolerance levels produced by the currently-used operational delivery system (D10-46 nozzle with a VMD of .750 um) to those produced by the AU5000 Micronair system (with a VMD of 250 um). A second objective of the trial is to define a reduced active rate, delivered with either system (D10-46 or Micronair), that would maintain or

improve the current standard of efficacy and crop tolerance.

A randomized-block design with four replicates was used for the experiment. The four blocks that were chosen each have reasonably uniform raspberry cover throughout, gentle topography, similar site history, and black spruce crops. Block sizes range from 30 to 62 ha. Considerable effort went into the selection of these four blocks, including the examination of 21 blocks and the sampling and anaysis of pre-treatment raspberry cover on 7 blocks. All of the blocks are located on Crown Land in New Brunswick; two approximately 90 km north of Fredericton, a third 18 km east of Edmundston, and a fourth 125 km north of Edmundston.

Each of the 4 blocks are subdivided into 9 treatment plots. These plots vary in size in order to take advantage of the terrain and are between 1.8 ha and 6.0 ha. Within each of the 9 plots, 25 subsamples have been systematically located along a transect that cuts across each plot diagonally. Each transect begins and ends at least 50 m inside the plot boundary to insure that sampling takes place well within the area planned to receive the calibrated dose. The subsamples are crop-tree centered, permanently marked, and consist of a 1-m sample radius, within which the percent cover of raspberry is estimated. The crop trees in the center of each subsample are rated on a scale of 0 (healthy) to 10 (dead). All pre-treatment data was recorded during July 1988.

Each of the four blocks contained the following 9 treatments:

1) D10-46 nozzles, 0.25 Kg ai/ha,
2) D10-46 nozzles, 0.50 Kg ai/ha,
3) D10-46 nozzles, 0.75 Kg ai/ha,
4) D10-46 nozzles, 1.00 Kg ai/ha,
5) AU5000 micronair, 0.25 Kg ai/ha,
6) AU5000 micronair, 0.50 Kg ai/ha,
7) AU5000 micronair, 0.75 Kg ai/ha,
8) AU5000 micronair, 1.00 Kg ai/ha,
9) untreated.

Two BELL 206B helicopters were used to apply these treatments, one equipped with micronaires, the other with the conventional nozzles. Both helicopters were flown by the same pilot, fitted with the same SIMPLEX spray system, and calibrated to deliver a total volume of 37.4 l/ha. Plots were clearly flagged on the ground so that the pilot was able to navigate accurately.

Treatment of the four blocks took place between September 4 and 10, 1988, all during early morning sessions. All 8 treatments were applied to each individual block during a single 2-hr spray session. Weather at the time of application was similar for 3 of the 4 blocks: winds light (0-3 kph), temperatures between 2 and

11 degrees C, and relative humidity (RH) between 88 and 100%. Due to limited budgets, 1 of the 4 blocks was treated in less than desirable conditions (winds 2 to 5 kph with occasional gusts to 10 and 20 kph) and the question remains as to whether or not its data will be usable. All treatments had a rain-free period of at least 18 hrs post application.

Since raspberry is the major competitor in N.B., efficacy is being measured by the relative change in pre- and post-treatment cover of this species. Crop tolerance is being evaluated as the relative change in health of the crop trees planted on the treated areas.

To help verify the results obtained in this trial, residue and deposit sampling was conducted. Petri dishes, containing glass-fibre filter paper, were placed within every fifth subsample area in each plot (5 per plot) in order to estimate impingement of active ingredient on target foliage at the time of application. A second set of petri dishes, placed in the same locations as the first, were used to detect potential contamination from adjacent treatments. 3M paper (#729), was also placed beside the residue sample locations in order to provide droplet spectra data for each of the treatments.

The data generated in this trial will be analyzed with regression techniques, with the intention of illustrating any differences in effectiveness between the two systems. As well, dose-response curves will be generated for each system with the hope of defining a reduced active rate that will still meet management efficacy objectives. Since the active ingredient represents 70% of total treatment costs, any reduction in the amount of active that can be made through the use of smaller droplet sizes would mean tremendous cost savings. Further, the results of this trial will allow the planning of future research that will be designed to seek out further cost savings in the interacting effects of carrier volume, spray timing, adjuvants, and droplet size.

Ongoing Operational Herbicide Research

Currently, FPMI has six active trials located across Canada. Four of these trials are located in New Brunswick, on J.D. Irving Ltd. freehold land at Black Brook.

The latest trial established at Black Brook was a June 1987 comparative study of VELPAR L (liquid hexazinone) and VELPAR ULW (Ultra-low-weight, dry-flowable hexazinone). Aerial application of a single active rate (2 Kg/ha) was used for this comparison. First-season weed efficacy results were presented at the 1988 Northeastern Weed Science Society (NEWSS) meeting (Pitt et al., 1988a). Half of the experiment was planted one month after treatment, the other half was planted this past August. Repeat measurements were made on the crop and weeds this August, and

crop tolerance and second-season weed efficacy data were presented at the 1989 NEWSS meeting (Pitt et al., 1989).

In 1986, a large-scale comparison of the site preparation herbicides VELPAR L, PRONONE 5G (5% granular hexazinone), and PRONONE 10G (10% granular hexazinone) was conducted at Black Brook. These herbicides were applied with ground-application equipment and the experiment was designed to compare several rates of each of the herbicides as well as spring vs fall soil application.

Also in 1986, along side of this VELPAR/PRONONE trial, a comparison of ALLY (metsulfuron-methyl) and OUST (sulfometuron-methyl) was established. Again, ground application equipment was used to apply several rates of each herbicide, but in this case, as spring soil and summer foliar applications.

For both of these 1986 trials, results of the spring applications were presented at the 1988 NEWSS meeting (Reynolds et al., 1988a; Reynolds et al., 1988b). Repeat measurements were made on the crop and weeds in these experiments this August, and results of the summer/fall applications and an update of the crop tolerance data were presented at the 1988 Expert Committee on Weeds (ECW) and 1989 NEWSS meetings (Reynolds et al., 1989a; Reynolds et al., 1989b; Reynolds et al., 1989c). Crop trees appear to show treatment-related growth differences this year and data will be analyzed and reported on later this winter.

The oldest FPMI trial established at Black Brook is a 1984 site preparation experiment involving VELPAR L. The trial encompasses about 40 ha and involved the aerial application of 3 different active rates. Since 1985, the trial has yielded valuable weed efficacy data which was reported in the 1986 Proceedings of the NEWSS (Reynolds et al., 1986). In 1987, emphasis shifted toward the crop tolerance and growth response aspects of this study and some very positive treatment effects were illustrated (Pitt et al., 1988b). In August 1987, half of the reps of this experiment were treated with VISION. Repeat measurements of the crop and weeds were made this August and future follow-up should provide some interesting site prep vs. site prep-and-release data.

Future work for FPMI in N.B. will involve the continuation of data collection from the above experiments as well as preparation for a 1989 comparative brush-herbicide trial. A site for this trial has been established on JDI freehold land near Dorn Ridge and, pending funding, treatment with GARLON, ALLY, ARSENAL, and VISION will take place in August.

References

Bode, L.E. and B.J. Butler. 1982. The three Ds of droplet size: diameter, drift, and deposit. World Agric. Aviation. May. p 37-79.

Brunsdon, B. 1988. Conversation at N.B.S.E.R.G. meeting, April 27-28, 1988.

Pitt, D.G., P. E. Reynolds and M. J. Roden. 1988a. Weed efficacy after site prep with liquid and dry-flowable hexazinone formulations. Proceedings of the Northeastern Weed Science Society, Supplement, 42:58-62.

Pitt, D.G., P. E. Reynolds and M. J. Roden. 1989. Crop tolerance and herbicide efficacy after site prep with liquid and dry-flowable hexazinone formulations. Proceedings of the Northeastern Weed Science Society, Supplement, Volume 43. In Press.

Prasad, R. and B.L. Cadogan. 1987. Influence of small droplets on herbicide efficacy. Proceedings of the A.C.A.F.A. Symposium, Oct. 23-25, Ottawa. p 1-12.

Prasad, R. and B. L. Cadogan. 1988. Role of droplet size and density on phytotoxicity of three herbicides. Weed Technology (in press) M. S. 25pp.

Reynolds, P.E., T.S. MacKay and M. L. McCormack, Jr. 1986. Results of a hexazinone-mechanical site preparation trial. Proceedings of the Northeastern Weed Science Society, 40: 222-229.

Reynolds, P.E., D. G. Pitt and M. J. Roden. 1988a. Weed efficacy and crop tolerance after site prep with liquid and granular hexazinone formulations. Proceedings of the Northeastern Weed Science Society, Supplement, 42: 74-78.

Reynolds, P.E., D. G. Pitt and M. J. Roden. 1988b. Weed efficacy and crop tolerance after site prep with sulfometuron-methyl and metsulfuron-methyl. Proceedings of the Northeastern Weed Science Society, Supplement, 42: 63-67.

Reynolds, P.E., D.G. Pitt and M.J. Roden. 1989a. Herbicide efficacy and crop tolerance after fall soil treatment with liquid and granular hexazinone formulations. Proceedings of the Northeastern Weed Science Society, Supplement, Volume 43. In Press.

Reynolds, P.E., D.G. Pitt and M.J. Roden. 1989b. Herbicide efficacy and crop tolerance after summer foliar treatment with sulfometuron-methyl and metsulfuron-methyl. Proceedings of the Northeastern Weed Science Society, Supplement, Volume 43. In Press.

Reynolds, P.E., D.G. Pitt and M.J. Roden. 1989c. Crop tolerance after spring soil treatment with hexazinone, sulfometuron-methyl and metsulfuron-methly. Proceedings of the Northeastern Weed Science Society, Supplement, Volume 43. In press.

REGULATORY ACTIVITIES

OPERATIONAL FOREST SPRAY MONITORING

W. A. SEXSMITH

The New Brunswick Department of the Environment has the mandate to regulate pesticide application in the Province, including both the spruce budworm spray program and the forest herbicide spray program (Table 1). The total number of man hours spent monitoring these programs for permit compliance was 100 and 110, with 2 and 0 incidents (complaints, etc.), respectively, investigated. One spill or jettisoned load occurred, relating to the forest herbicide spray program (Table 2). No significant environmental impact was observed as a result of the spill.

Setbacks or buffer zones, have been used as a regulatory tool over the years in New Brunswick as a means to protect designated sensitive areas from impact of spray operations. Setbacks that were in place for 1988 for the forest insecticide spray program are indicated in Table 3 and for the forest herbicide spray program, Table 4.

Setbacks for research applications, not indicated in the tables, were 8 km from human habitation for a new (unregistered) active ingredient, and 3.2 km from human habitation for a previously registered active ingredient.

These buffer zones, although there have been few changes in the past few years, are not meant to be static but are such that they may change as the information available changes.

TABLE 1. 1988 PESTICIDE USE IN FORESTRY IN NEW BRUNSWICK (AERIAL)

AGENCY	PRODUCT	PEST	HECTARES	RATE (a.i./ha)
INSECTICIDES				
Forest Protection Ltd.	FEM[1]	Budworm[2]	231080	210 g/ha[3]
	FEM		6273	280 g/ha
	Dipel 132[4]		26482	30 BIU/ha
	Futura XLV[4]		184038	30 BIU/ha
	Futura XLV		391	90 BIU/ha
	Futura XLV and FEM		603	30 BIU/ha 210 g/ha
J.D. Irving Ltd.	FEM	Budworm	14581	210 g/ha
	FEM		68867	210 g/ha[3]
	Dipel 176[4]		4581	1.78 l/ha
	Dipel 176 and FEM		10175	210 g/ha 1.78 l/ha
	FEM	Budmoth[5]	9391	105 g/ha
Forestry Canada (experimental)	Futura XLV HP[4]	Budworm	400	15 BIU/ha
			800	30 BIU/ha
	Futura XLV[4]		450	30 BIU/ha
	Foray 48 B[4]		200	30 BIU/ha
	CIL E 492[4]		200	30 BIU/ha
	Dipel 12 L[4]		400	15 BIU/ha
	Dipel 16 L[4]		400	30 BIU/ha
			400	15 BIU/ha
			400	30 BIU/ha
University of New Brunswick (experimental)	E/Z-11 Tetradecenal[6]		25	20 g/ha
			25	90 g/ha
HERBICIDES				
Department of Natural Resources	Vision[7]	hardwoods and herbaceous vegetation	14271	4.36 l/ha
			3361	5.01 l/ha
Forest Pest Management Institute (experimental)	Vision		59.3	0.25 kg/ha
			60.4	0.50 kg/ha
			57.7	0.75 kg/ha
			49.4	1.0 kg/ha

TABLE 1. (continued) 1988 PESTICIDE USE IN FORESTRY IN NEW BRUNSWICK (AERIAL)

J.D. Irving	Vision	1276	4.9 l/ha
		844	4.2 l/ha
J.D. Irving	Vision	14491	3-3.7 l/ha
			4.2 l/ha[8]
			3.46 l/ha[9]
Monsanto	Vision	40	3-6 l/ha
Fraser Inc.		5300	4.271 l/ha
NBIP	Vision	938.6	4.5 - 5.5 l/ha

1 fenitrothion

2 spruce budworm

3 Two applications

4 Bacillus thuringiensis

5 spruce budmoth

6 pheromone - spruce budworm

7 glyphosate

8 This rate was used on 182 ha only.

9 This rate was used on a portion of a 494 ha block.

TABLE 2. PESTICIDE SPILLS/HETTISONED LOADS IN OPERATIONAL FORESTRY PROGRAMS IN 1988.

Date	Agency	Product	Amount	Location	Cause
Aug. 18	Natural Resources	glyphosate	34L	Blue Mountain	Helicopter had difficulty clearing trees

TABLE 3. SETBACKS FOR THE 1988 SPRUCE BUDWORM SPRAY PROGRAM IN NEW BRUNSWICK

	Woodlands*		Woodlots**	
	H_2O***		H_2O	B.t.
Habitation	1.6 km		300 m	155 m
Lakes (> 40 ha)	400 m			
Designated major Rivers	400 m			
Open water bodies			65 m	0
Ecological reserves	400 m		65 m	65 m
Municipal water (point of extraction)	3.2 km		3.2 km	3.2 km
Blueberry fields	3.2 km		3.2 km	0

* TBM aircraft
** Agricultural type aircraft
*** Water-based chemical formulation

TABLE 4. SETBACKS FOR THE 1988 FOREST HERBICIDE SPRAY PROGRAM IN NEW BRUNSWICK

Habitation	155 m
Open water bodies	65 m
Municipal water (point of extraction)	3.2 km

Monitoring in other jurisdictions

Environmental monitoring carried out for the aerial spraying of biological insecticides against the Spruce budworm in Quebec in 1988.

S. Delisle, P.-M. Marotte and J. Cabana

INSECTICIDE SPRAYING AGAINST THE SPRUCE BUDWORM

For the past two years, the Ministere d'Energie et Ressources (MER) has used mainly B.t.k. - based (Bacillus thuringiensis var. kurstaki) biological insecticides to control the spruce budworm (Choristoneura fumiferana Clem.). Several studies have shown that B.t.k. poses no threat to man, wildlife or the environment in general. However, insecticides made from this bacteria contain spores that may persist, reproduce and even accumulate under suitable conditions. The MER has therefore decided that the short and long-term presence of these spores should be assessed. An annual sampling program has been implemented for this purpose.

In 1988, the MER operational spray program covered an area of 192 073 hectares. Dipel 132 was sprayed over 93% of the zone and Futura XLV over the remaining 7%. Two four-engine DC-4 aircraft and 12 single-engine Bull Thrush, Thrush 800 and AgCat aircraft applied the insecticides at a dosage rate of 30 BIU/ha.

The results of various experimental treatments will be discussed later.

1. Long-term Persistence of B.t.

a) Forest Soil

- Thuricide 48LV

In 1985, the MER established 29 forest soil sampling sites in the areas treated with Thuricide 48LV. Since then, these sites have been sampled annually to assess the persistence of this product. Over the years, some sites have had to be abandoned, however, for various reasons. In 1988, 16 sites were sampled. The aim of our study was to verify whether Thuricide 48LV was still present in the soil three years after treatment and whether there had been an increase in the concentrations of this product in the mineral layer. Thirty-two samples were analyzed during the study and the results are presented in Table 1.

- Dipel 132

In 1987, the MER studied the behaviour of Dipel 132 in the soil after aerial spraying. Since no research had been carried out on the long-term behaviour of this product, the MER wanted to assess its persistence one year after treatment. It also wanted to evaluate the downward movement of B.t. spores in the soil and to compare the results with those of the Thuricide 48LV study.

The 18 sites sampled in 1987 were sampled again this year. Thirty-six organic and mineral soil samples were collected. The results are presented in Table 1.

b) Lakes

In 1987, the MER took sediment and water samples from a number of lakes two months after the area in which these lakes were located had been treated with Dipel 132. A total of eight lakes were sampled during the study. Low concentrations of this insecticide could still be detected in the samples from lakes whose watershed had been exposed to spraying.

The lakes were sampled again in 1988 to assess the persistence of Dipel 132 one year after spraying. Five sediment samples and three water samples were taken from each lake. The results are shown in Table 1.

2. Short-term Persistence of Dipel 132 in the Soil

During a study conducted in 1987, very small quantities of B.t. were detected in the soil a few days after Dipel 132 had been applied. The concentrations were, however, lower than those recorded after treatment with Thuricide 48LV. These results are difficult to explain since both formulations contain the same amount of spores per litre.

A similar study was carried out in 1988 to determine the short-term behaviour of Dipel 132. Twelve samples of organic soil were collected one to three days after spraying. The results of this study are shown in Table 1.

3. Monitoring Experimental Products

Treatments must be tested in the forest before new insecticides may be approved by Agriculture Canada. The MER is currently participating in projects aimed at measuring the effectiveness of certain experimental products and studying their behaviour in the environment. Two of the products used by the Department in 1988 were aqueous B.t.k.-based formulations. Developed by CIL and Ecogen Inc., these products are known as E492 and Condor AF.

Table 1. Short and Long-term Persistence of B.t.- Preliminary Results

PROJECT	ENVIRONMENT	PRODUCT	SAMPLING DATE AFTER TREATMENT	MIN. - MAX.
long-term persistence	org. soil[a]	Th.48LV	3 years	2.3 - 33.0 x 10^4C.F.U.[c]/g
	min. soil[b]			N.D.[d]- 1.6 x 10^4C.F.U./g
-	org. soil	Dipel 132	1 year	N.D. - 28.0 x 10^4C.F.U./g
	min. soil			N.D. - 0.31 x 10^4C.F.U./g
-	lake-sediment	Dipel 132	1 year	N.D.[e]- 0.62 x 10^4C.F.U./g
-	lake-water	Dipel 132	1 year	0.001- 0.18 x 10^4C.F.U./l
short-term persistence	org. soil	Dipel 132	1-3 days	1.1 - 21.0 x 10^4C.F.U./g

a. org. soil: organic soil
b. min. soil: mineral soil
c. C.F.U.: colony forming units
d. N.D. (soil): not detected <0.1 x 10^4C.F.U./g dry weight
e. N.D.(sed.): not detected <0.01 x 10^4C.F.U./g wet weight

a) E 492(CIL)

In the spring of 1988, the MER used two formulations of this product during its aerial spraying program against the spruce budworm. Four forest sectors covering a total of 144 hectares were treated. A Piper Pawnee aircraft applied the insecticide at a rate of 30 BIU/ha.

As a follow-up to spraying operations, the MER carried out a sampling program in collaboration with CIL. Samples were taken in two types of environment: forest soil and lotic water. The primary objective of the program was to determine the short, medium and long-term behaviour of E492. The MER also intends to compare the results of this study with those of the Thuricide 48LV and Dipel 132 studies.

To ascertain the behaviour of E492, the MER sampled 16 soil sites and one stream during the spring and summer. An initial series of samples was taken prior to spraying operations. The soil sites were sampled again on two other occasions: one to three days and three months after treatment. In the stream, samples were collected every 20 minutes during the first three hours after spraying. Other samples were taken one day, four days and two months after treatment. In all, 48 organic soil samples, 32 mineral soil samples and 13 water samples were collected during the study. The same sampling sites will be studied again in the spring of 1989.

b) Condor AF (Ecogen)

In September 1988, the MER implemented a ground spraying program in collaboration with Ecogen Inc. The primary objective of the program was to determine the behaviour of Condor AF in both organic and mineral soil.

During the study, eight forest soil sampling sites were treated manually with a pneumatic sprayer at a dosage rate of 30 BIU/ha. For comparative purposes, eight other sites were treated in the same manner with Dipel 132. An initial series of samples was taken prior to spraying operations. Other samples were taken 24 hours and 2 months after treatment. In all, 80 samples or organic and mineral soil were collected. These sites will be sampled again nine months after spraying.

Environmental Monitoring Carried out for the Aerial Spraying of Insecticides Against the Spruce Budmoth in Quebec in 1988

S. Delisle, and P.-M. Marotte

SPRAYING AGAINST THE SPRUCE BUDMOTH

In May 1988, the Ministere d'Energie et Ressources (MER) implemented an experimental spray program against the spruce budmoth (Zeiraphera canadensis). Spraying operations covered a total of 35.1 hectares, spread out over 10 white spruce plantations. The insecticides diflubenzuron (Dimilin) and permethrin (Pounce) were used during the program. They were applied by a Hughes 269C helicopter, at a dosage rate of 140 and 280 g/ha, in the case of diflubenzuron, and 70 g/ha, in the case of permethrin.

Since these insecticides might be used during operational spray programs, the MER wanted to determine how they behaved in the environment. For this purpose, it assessed their deposition after spraying. It also measured diflubenzuron concentrations in the soil and foliage.

1. Deposition

The MER measured diflubenzuron and permethrin deposits on six different occasions during the experimental program. During each treatment, five collectors containing Kromekote paper and a sheet of aluminum foil were installed near the crown of trees. These collectors detected concentrations which, when expressed as a percentage of the dosage rate, varied from 44 to 83% in the case of diflubenzuron and from 51 to 100% in the case of permethrin.

2. Soil and Foliage

Soil and white spruce foliage samples were taken in the plantations sprayed with diflubenzuron. The MER wanted to assess the short and medium-term persistence of this insecticide.

Four soil and four foliage sampling stations were studied during the program. An initial series of samples was collected prior to spraying. Other samples were taken 9 to 16 hours, two weeks and two months after treatment. In all, 24 foliage and 16 organic soil samples were collected.

Environmental Monitoring of Herbicide Spraying Carried out in Quebec in 1988

J. Legris and S. Delisle

SPRAYING HERBICIDES ON PUBLIC LAND

To complete our knowledge of the behaviour of the herbicides used in the forest environment by the Ministère d'Energie et Ressources (MER) and to validate the data collected to date, monitoring of glyphosate (Vision) and hexazinone (Velpar L) in the environment over the past year has continued.

1. Glyphosate

Forty water, 30 sediment and 60 soil samples were taken following the implementation of a ground spraying program involving the herbicide glyphosate. During an experimental aerial spraying program, a study was conducted to quantify the deposition and drift of this herbicide using three types of collectors: Petri dishes, aluminum foil and Kromekote paper. A total of 250 samples were collected for this purpose.

In measuring the amount of residues present in biological components, the focus was primarily on land animals. Nineteen snowshoe hares living in or near the treated zones were captured. Samples of the animals' muscle, liver, kidneys, stomach contents, faeces and urine were collected for subsequent analyses. Muscle, kidney and liver samples were also taken from moose and deer killed in or near the sectors where glyphosate had been applied. Fourteen samples of wild fruit and three samples of aquatic plants were also collected during this monitoring program.

2. Hexazinone

The hexazinone monitoring program was somewhat more limited than that carried out for glyphosate since hexazinone is not used very widely in Québec. Nevertheless, a few water, sediment and soil samples were taken. In addition, to determine the doses to which workers may be exposed, air samples were collected while this herbicide was applied with spotguns.

3. Collaboration in Other Projects

In 1988, the Canadian Wildlife Service conducted a study on the long-term impact of herbicides on bird populations. The MER contributed financially to the project and was also involved at several stages during its implementation.

A three-year agreement has also been concluded with the Centre de Toxicologie du Québec to determine the extent to which forest

workers are exposed to pesticides during their operational use in nurseries and forests.

1988 Hemlock Looper Control Monitoring Program in Newfoundland

R. Martin

Forestry Canada's forecast for 1988 hemlock looper populations indicated that a total of 166,115 hectares including 117,756 hectares in the moderate and severe defoliation category were expected and situated mainly in western Newfoundland, with the major areas located on the Great Northern Peninsula.

Based on these figures, the Department of Forestry and Agriculture in conjunction with the two pulp and paper companies (Corner Brook Pulp and Paper and Abitibi Price) proposed a control program using formulations containing fenitrothion and Bacillus thuringiensis (B.t.). The proposed treatment areas totalled 74,650 hectares and consisted of 21 blocks (48,702 ha) to receive two applications (minimum 4 to 6 days apart) of fenitrothion applied at 210 g ai in 1.5 litres per hectare per application in an oil-based formulation, and 12 blocks (25,948 ha) to receive one application of B.t. at 30 BIU and applied undiluted. Futura XLV was to be applied to three blocks and the remainder was to receive Dipel 176.

The Department of Forestry and Agriculture was required, as part of their operator's licence conditions, to carry out a songbird monitoring program. As with the monitoring studies carried out in the two previous years, brain cholinesterase (ChE) activity in white-throated sparrows (Zonotrichia albicollis) was monitored as an indicator of exposure to fenitrothion. The 1988 monitoring program was also attempted to examine ChE recovery in birds exposed to the organophosphorous insecticide. For the purposes of the 1988 and previous years studies, the criteria of two scientists, Zinkl and Ludke, were used to determine what proportion of birds in a spray block had been exposed to fenitrothion. The criteria specifically stated that if an individual bird's ChE activity level experienced a 20% or greater, inhibition then it could be concluded that the bird had been exposed to fenitrothion. If, on the other hand, a bird's ChE activity had experienced a 50% or greater, decrease in activity then it could be concluded that the bird had been exposed to a potentially life threatening dose of the insecticide.

Given these criteria, a number of birds in the fenitrothion spray blocks were collected and their brain ChE activity determined. These values were compared with birds not exposed to the insecticide. From these data it was determined that 58% of collected birds had been exposed to fenitrothion. Approximately 9% indicated exposure to potentially life threatening doses.

Comparatively speaking, the overall measurable effect on songbirds of the operational spray delivery in 1988 was less than that observed in the 1987 and 1986 programs. However, in 1988, severe abnormal behaviour in songbirds was observed by field personnel for the first time.

With respect to the question of recovery from exposure to fenitrothion it was found that the maximum depression in ChE activity was observed on the first day after the first spray. An apparent rapid recovery in ChE activity was observed on the third day. ChE activity levels following the second spray did not follow the same response curve as those monitored after the first spray. A more prolonged depression in ChE activity was observed. The reasons for this difference is not understood at this time.

RECENT PUBLICATIONS

Ernst, W. R., P. A. Pearce, and T. L. Pollock. 1989. Environmental effects of fenitrothion use in forestry. Environment Canada, Conservation and Protection, Atlantic Region. 166 pp.

Irland, L.C., J.B. Dimond, J.L. Stone, J. Falk and E. Baum. 1988. The spruce budworm outbreak in Maine in the 1970's-assessment and directions for the future. Maine Agricultural Experiment Station. Univ. Maine. Orono. M.E. 04469 Bulletin 819.

Reynolds, P.E. Ed. 1989. Proceedings of the Carnation Week Herbicide Workshop. FRDA report 063. B.C. Ministry of Forests, Research Branch, 32 Bastion Square, Victoria B.C. V8W 3E7.

AUTHORS' AFFILIATIONS AND ADDRESSES

J. Cabana — 418-643-2922
Ministere de L'Energie
et des Resources
1530, boul, de l'Entente
Quebec, Quebec
G1S 4N7

N. Carter — 506-453-2516
Natural Resources and Energy
P.O. Box 6000
Fredericton, N.B.
E3B 5H1

S. Delisle — 418-643-2922
Ministere de l'Energie
et des Resources
1530, boul, de l'Entente
Quebec, Quebec
G1S 4N7

S. E. Holmes — 506-452-3500
Canadian Forestry Service, Maritimes
P.O. Box 4000
Fredericton, N.B.
E3B 5P7

E. G. Kettela — 506-452-3500
Canadian Forestry Service, Maritimes
P. O. Box 4000
Fredericton, N.B.
E3B 4P7

J. Legris — 418-643-2922
Ministere de L'Energie et des Resources
1530, boul, de l'Entente
Quebec, Quebec
G1S 4N7

P. M. Marotte — 418-643-2922
Ministere de L'Energie et des Resources
1530, boul, de l'Entente
Quebec, Quebec
G1S 4N7

R. Martin — 709-576-3858
Government of Newfoundland and Labrador
Department of Environment
Box 4750
St. John's, Newfoundland
A1C 5T7

P. C. Nigam
Canadian Forestry Service-Maritimes
P.O. Box 4000
Fredericton, N.B.
E3B 4P7
506-452-3500

D. Pitt
Forest Pest Management Institute
Canadian Forestry Service
P.O. Box 490
Sault Ste. Marie, Ontario
P6A 5M7
705-949-9461

W. A. Sexsmith
Environmental Protection Branch
Department of the Environment
P. O. Box 6000
Fredericton, N. B.
E3B 5H1
506-453-2861

Further information or additional copies of this report may be obtained by contacting the Secretary to EMOFCO, Environmental Protection Branch, Department of the Environment, Province of New Brunswick, Box 6000, Fredericton, New Brunswick, E3B 5H1. (506-453-2861).